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3. It seems reasonable to assume that all meteors belonging to the same shower have nearly the same *real* length of path; the apparent length varies with the distance from the radiant. Since then an inordinately great or small weight—about 5 times or $\frac{1}{5}$ the mean weight for a given observer—indicates that the path of the meteor is not of a length proportionate to its distance from the radiant, it follows that the weights are to a certain extent a criterion of a meteor's right to be included in the determination of the radiant. But Mr. Denning's words, "radiant points should be determined by the observer of the meteors," must be remembered; the calculator must only include meteors which the observer gives him labelled as *Perseids*.

4. The effect of zenith attraction, rotation, and orbital motion of the Earth on one night's observations may be neglected as insensible in the case of the *Perseids*.

5. Assuming the radiant of this shower to be a point—

A. The probable error of a recorded beginning or end of a meteor's path varies so far as direction of path is concerned from ±0°·2 to ±1°·6.

B. To get a reliable determination of the radiant the more meteors made use of the better.

C. The probable error of a radiant derived from about 20 to 30 meteors varies from ±0°·2 to ±1°·0.

6. Assuming the radiant to be an area—

A. There are indications of a change in size of this area.

7. A discussion of observations of meteors belonging to other strong showers would decide the question of how much of the probable error here found is due to error of observation, and how much to real diffuseness of radiant.

8. The position of a radiant point derived from Mr. Denning's observations may be relied upon to within three-quarters of a degree of great circle, and I think that the present discussion, so far as it goes, makes it clear that eye-observations are of sufficient accuracy to show the existence of stationary radiants. Very great care must be taken in combining meteors to form a radiant, and if there is any doubt as to the reality of stationary radiants it is on this point, and not on the accuracy of the record of path, that it rests.

Leonids observed at Cambridge Observatory, 1900 *November* 13, 14, 15. By J. C. W. Herschel, B.A.

(*Communicated by Sir Robert Ball.*)

[The arrangement for observing the *Leonids* in 1900 was entrusted to Mr. J. C. W. Herschel, Research Student at the Observatory. He was assisted by the following members of the

University, to whom our obligations are due: Messrs. A. G. Whitehouse, B.A., Queens' College, L. N. G. Filon, King's College, J. A. Hubback, King's College, P. M. Marples, B.A., Jesus College, H. D. Wakely, St. John's College, and H. A. Webb, Trinity College.—ROBERT S. BALL.]

There were two objects in view: to keep a continuous count of all meteors seen per quarter hour; to record as many of these as were sufficiently well observed. The latter object practically covered the former. The track of a meteor was marked down *at once* on a blue map with needle-hole stars illuminated from behind, as described by Mr. Hinks in his paper on the Leonids of 1899 (*Monthly Notices*, April 1900). It is to the use of these maps that I attribute the compactness of the radiant areas, for the tracks are recorded in the most concise manner—a single line—in the form and place in which they are required and used throughout. Errors of intermediate steps are avoided, such as plotting down from notes.

Schiaparelli's geometrical method of combining tracks for the deduction of radiant points was used.

In the following table the second line includes those only "seen" but not "plotted"; the Leonids in the third line have already been counted under "plotted," and although a small number of those only "seen" were noted as "probably Leonids," they may be treated as a whole as belonging to other radiants.

Nov. 13. Period from	13^h	½	14^h	¼	½	¾	15^h	¼	½	¾	16^h	¼	½	¾	17^h	¼	½	¾	To
Plotted.	1	4	2	4	1	1	3	2	1	1	3	4	4	3	6	4	2	...	4
Seen.	1	4	...	...	...	...	...	1	1	...	2	2	4	1	4	...	4	...	2
Leonids.	1	2	1	2	...	...	1	1	...	...*	1	3	...	1	4	...	...	...	1

* Cloudy 10 minutes. Hazy all night with light clouds scattered about.

Nov. 14. Period from	$12\frac{1}{2}^h$	¾	13^h	¼	½	¾	14^h	¼	½	¾	15^h	Tot
Plotted.	2	2	6	10	5	3	1	...	4	...	2	3
Seen.	...	5	5	6	7	4	...	1	...	...	...	2
Leonids.	...	...	2	3	1	...	1	...	2	...	...	

After 14^h clouds, getting gradually thicker.

Nov. 15 Period from	$11\frac{1}{4}^h$	½	¾	12^h	¼	½	¾	13^h	¼	½	¾	14^h	¼	½	¾	15^h	Tot
Plotted.	2	4	4	6	3	3	3	4	4	3	5	...	5	3	1	1	5
Seen.	2	3	...	2	4	3	2	6	4	3	2	4	1	1	...	...	3
Leonids.	1	2	...	1	...	2	2	3	4	1	1	...	2	1	1	1	2:

Misty till 11^h, clear till 15^h, afterwards thick clouds.

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These figures show that the display of Leonids was very weak this year, with a slight access of strength on the 14th between $13\frac{1}{4}^h$ and $13\frac{1}{2}^h$, and a maximum on the 15th at about 13^h. It has been pointed out to me by Professor A. S. Herschel that the activity of neighbouring showers in several instances seems to fluctuate in sympathy with the chief shower. These numbers confirm this.

Now as to the radiant points deduced.

All the meteors which were plotted as coming from within and close round about the Sickle were considered *Leonids*, and only these, 48 in number, are here discussed. They were in general green with broad green streaks, though some were noted as "reddish," "yellow" or "bluish."

On the 13*th* 46 meteors were plotted, of which 17 were Leonids.

9 meteors definitely showed the radiants I. and VI.
7 ,, supported the radiants II., III., IV., V.
1 meteor was not assigned.

This last meteor was an outlying one, and though its line passed only 2° outside radiant I., to take count of it would much weaken the very definite determination of this radiant point, as will be seen below. (See table, columns 5 and 6.)

The determination of radiant V. is illustrative. The above seven meteors formed a somewhat loose radiant area at about 151°+29°; but when combined with the other two nights' observations, it turned out that the support of five of them was illusory—at least they fitted other radiants better. The two that remained crossed each other a little way below the mean centre of the seven, and fortunately three meteors were seen on the 15th which admirably supported the lowered position, and led me to re-assign one of the five to this radiant.

Radiants I. and VI. were active only on this night.

On the 14*th* 35 meteors were plotted, of which 9 were Leonids.

7 meteors definitely showed radiants II. and IV.
2 ,, supported radiants III. and VI.

On the 15*th* 51 meteors were plotted, of which 22 were Leonids.

19 meteors definitely showed the radiants II., III., IV., VII.
3 ,, supported radiant V. of the 13th.

Radiant VII. was active only on this night.

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The following table sums up the results.

No.	Name.	Rad.	Point.	Number of ↓'s.			Total.	Mean deviation.	Diam. of includg. circle.	Nearest Radiants in Denning's Catalogue.
		α	δ	13th	14th	15th				
I.	ξ Leonids	141°·8	+17°·3	4	0	0	4	0°·7	1°·1	CIX. 4.
II.	μ Leonids	143·4	+25·3	2	3	4	9	0·8	1·5	CVIII. 6; CXV. 18, 1
III.		147·5	+22·4	1	1	4	6	0·5	2·3	CXV. 5, 6, 12, 97 *et al.*
IV.	Great	150·5	+15·5	1	4	6	11	0·8	4·0	CXV. 56, 100.
V.	Leonid	151·9	+27·8	3	0	3	6	0·5	1·8	CXV. 68, 71.
VI.	Shower	153·0	+20·3	5	1	0	6	0·6	2·4	CXV. 80, 102, 103 *et a*
VII.	α Leonids	156·6	+18·7	0	0	5	5	0·2	0·8	CXV. 21, 61; CXX. 7.
	Unassigned			1	0	0	1	2° from radiant I.		
				17	9	22	48			

Columns 6 and 7 give a measure of the reliability of the observations. Were all these meteors plotted on one map their lines of direction would cross each other over the whole Sickle, and it would not be very unreasonable to treat them as rough observations, and find an average central point for the whole lot. But they are worth more trouble. Closer study has shown that these 48 meteors, *which are all the Leonids that were plotted*, belong to the seven distinct and definite radiant points enumerated above. With three exceptions (both about 2°) the direction of every meteor passes within $1\frac{1}{2}^\circ$ of one of these radiant points; only 6 exceed the degree; and the average deviation is only about $\frac{2}{3}^\circ$. The tracks have not been altered in any way, and no theoretical corrections have been applied. This result is more defined than could have been expected.

I wish to draw attention to the concordance in place of radiants III., IV. and VI. with the radiants CXV., 97, 100, 102 in Mr. Denning's Catalogue, recorded there as having been noted, by Professor Brackett's observing party at Claremont, California, on 1898 November 12, 15, and 17, at $147\frac{1}{2}+22$, $150+17\frac{1}{2}$, $152\frac{1}{2}+22$. Such a concordance has, I think, additional weight because the three radiants were in each case noted as distinct by a single party of observers; the corroboration is not merely one found by selecting single places noted independently of each other by different observers with sensible variation of position.

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On a Method of Reducing Occultations of Stars by the Moon; together with the Reduction of Occultations observed on Three Occasions at the Liverpool Observatory. By H. C. Plummer, M.A.

The present paper is the result of an undertaking to reduce three series of observations of occultations and to render them available for the discussion of the Moon's semi-diameter. As I was not acquainted with a method which did not seem to leave something to be desired in point of clearness or convenience, I adopted one which offers certain considerable advantages. This method seems to differ essentially from those which have been previously employed, and it therefore appears desirable to describe it in some detail. The first object of the theory is to obtain a quite general equation expressing the geometrical conditions, on the assumption that the figure of the Moon is a sphere and that the line joining the observer to the star is a tangent line to the Moon at the time of the observation.

Let (x, y, z) be the position of the observer; (X, Y, Z) of the centre of the Moon; and (l, m, n) direction cosines of the star, referred to rectangular geocentric axes. Let R be the radius of the Moon. Then

$$\frac{\xi-x}{l}=\frac{\eta-y}{m}=\frac{\zeta-z}{n}$$

$$\frac{\xi-x}{X-x}=\frac{\eta-y}{Y-y}=\frac{\zeta-z}{Z-z}$$

represent the lines joining the observer to the star and to the centre of the Moon respectively. If, now, ψ is the angle between these lines,

$$l(X-x)+m(Y-y)+n(Z-z)$$
$$=\cos\psi\,.\,\sqrt{\{(X-x)^2+(Y-y)^2+(Z-z)^2\}}\,;$$
$$R=\sin\psi\,.\,\sqrt{\{(X-x)^2+(Y-y)^2+(Z-z)^2\}}\,;$$
$$\therefore\ \{l(X-x)+m(Y-y)+n(Z-z)\}^2+R^2$$
$$=(X-x)^2+(Y-y)^2+(Z-z)^2.$$

Now let ρ be the Earth's radius and ϕ the geocentric latitude at the place of observation; T, the sidereal time (or R.A. of the zenith); A, D, the apparent R.A. and declination of the star; α, δ, the geocentric R.A. and declination of the Moon. Also let r, P, s be the Moon's radius vector, parallax, and semi-diameter respectively. Then, if the axis of x has been taken through the First Point of Aries and the axis of z through the Pole,

$$X=r\cos\delta\cos\alpha\,;\quad Y=r\cos\delta\sin\alpha\,;\quad Z=r\sin\delta\,;$$
$$l=\cos D\cos A\,;\quad m=\cos D\sin A\,;\quad n=\sin D\,;$$
$$x=\rho\cos\phi\cos T\,;\quad y=\rho\cos\phi\sin T\,;\quad z=\rho\sin\phi.$$